Risks and Benefits of Pool Chlorination, with Manolis Kogevinas

Ashley Ahearn

Chlorine is one of the most common disinfectants used to kill microbes in water and make it safe for humans to swim in and drink. But when chlorine and other disinfectants combine with organic matter in pools such as sweat, urine, and skin cells, the results are disinfection by-products (DBPs), which have been linked with adverse health effects in animals and humans. In this podcast, Manolis Kogevinas discusses recent research on the carcinogenic and genotoxic potential of DBPs, but he also explains why people don't necessarily need to stop swimming in pools. Kogevinas is a professor and co-director of the Centre for Research in Environmental Epidemiology in Barcelona, Spain.

AHEARN: It's *The Researcher's Perspective*. I'm Ashley Ahearn.

Ahhh, the smell of chlorine—it brings back childhood memories of summer camp, swim class, maybe the high school swim team…

Chlorine is one of the most common disinfectants used to kill microbes in water and make it safe for humans to swim in and drink.

But when chlorine and other disinfectants combine with organic matter in pools such as sweat, urine, and skin cells, the result is disinfection by-products, or DBPs. And these DBPs have been shown to be carcinogenic in animals.[1]

Dr. Manolis Kogevinas is a professor and co-director of the Centre for Research in Environmental Epidemiology in Barcelona, Spain. He has been involved in a series of studies on swimmers to explore the effects of their exposure to DBPs, and he recently coauthored a set of papers in *EHP*[2,3,4] on that research.

Dr. Kogevinas, thanks for being here.

KOGEVINAS: Thank you.

AHEARN: Why don't you start by telling us about the studies of pool water and swimmers that were conducted in Barcelona, and tell me, what you were trying to find?

KOGEVINAS: Well, we asked a set of volunteers to swim for 40 minutes in a chlorinated pool, and we measured what happened before and after, and we wanted to see whether, in a real-life situation, we could identify some of the effects that have been identified in the lab.

AHEARN: And what did you find?

KOGEVINAS: Well, we found—to our surprise, to some extent—that we indeed could identify some of the effects that are related to cancer. So we evaluated biomarkers; we didn't evaluate disease—these were all healthy individuals swimming. And we saw that when we compared levels of biomarkers before swimming and just after a 40-minute swim, some of the ones that are associated with cancer were increased in blood and urine. And we didn't find big effects in the respiratory system, in the lung epithelium; that is, the other big group of diseases that could be associated with swimming in a pool. So, overall, the evidence from studies in children going to swimming pool[s] indicates that there is no association with asthma. And now we have in press, also, a new study[5] that looks prospectively at children going to swimming pool[s] and, in fact, we see that asthmatic children going to swimming pool[s] improve their lung function by going to the swimming pool. So we don't have an indication that it is actually associated with asthma in real-life conditions of the general population—I'm not talking about the elite swimmers.[6]

AHEARN: Let's talk about DBPs. What are they, exactly?

KOGEVINAS: They are a set of 600, 700 compounds. So there are quite a few of them that are created through the interaction of chlorine with the organic material that's in the water. And in the swimming pool we have the material that's in the tap water normally, but we have a continuous introduction of new organic material.

AHEARN: So that's why I have to take a shower before I get in the swimming pool.

KOGEVINAS: Exactly. So as not to introduce sweat and to introduce less organic material.

AHEARN: What do these chemicals do in the body?

KOGEVINAS: They may be affecting our DNA, and this is what we are testing. And we did find an increased mutagenicity, and we did find this affects the micronucleus assay—that means that they may produce some gross damage in the DNA.[7]

We have increasing evidence that DBPs in tap water (we don't have studies, long-term studies, in swimmers) may be associated with increased bladder cancer.

AHEARN: So we use the same chemicals to decontaminate our swimming pools as we do to decontaminate our drinking water. I'm wondering, are DBPs a concern in drinking water as well, and if so, how are those exposures different between say, swimming a few times a week and drinking tap water?

KOGEVINAS: DBPs are very similar in the tap water and the swimming pools. They're not exactly the same because we have [a] different type of organic material[8]—in the drinking water you don't have, [for instance,] sweat—so you have some kind of a different composition, but you still have the trihalomethanes as one of the main DBPs,

haloacetic acids, so that's why the findings that we have in the swimming pool are relevant for the tap water and vice versa.

AHEARN: Chlorine is critical for purifying contaminated drinking water in many developing countries. I mean, what's worse, microbes or cancer risk, and is that even a fair question?

KOGEVINAS: I think that's a fair question. Having clean water has been among the major public health achievements we had last century, and chlorine is very efficient as a disinfectant, and it's cheap. So I would not dream of saying to anybody in a poor country "oh hey, don't use chlorine because it may increase, you know, your urine mutagenicity or whatever," or even "it may increase your bladder cancer" when they have a really serious problem. And this may sound cynical, that we are having different standards, but it's not cynical; it is just priorities. Priorities in a poor country with no clean water are: get clean water, and then we can talk about some of the other risks that go along with the clean water.

AHEARN: So that strong chlorine smell at the pool—is that necessarily a bad thing? Should I change pools or, you know, swim in the ocean or lakes instead?

KOGEVINAS: (laughs) Well, I mean, if you live by the ocean and you like swimming in the ocean, swim in the ocean, but you know, most people can't do that, so we will have to use swimming pools. And then, you know, if you want to do physical exercise, frankly speaking, it's much easier to do it in a pool than in the ocean. But yes, I mean there is really space for improvement of our indoor swimming pools. I know that—at least, I'm talking for Spain—I mean, we already had a meeting with the Spanish Association of Swimming Pools, and they seemed quite committed to evaluate the swimming pools in Spain, and they thought that yes, there are lots of swimming pools that are not that well controlled: ventilation is not adequate, the amount of chlorine that is added is not very well measured, and then there's not always good control and adequate education of the swimmers. The regulations we have, or the way they are applied, do not function, at least here in Spain. For example, the swimming pools keep the water for years. They just filter it, but they don't change it. We'll have to evaluate whether we may have to introduce fresh water, we may have to change the water more frequently. So there are things that can be reevaluated, but this is more an issue of engineering and of chemists rather than of MDs like me to say.

AHEARN: So how many times a week do you swim?

KOGEVINAS: (laughs) I don't swim much, actually. I go to the gym, but I don't swim much. But this is not that I'm a hypochondriac. I just, I never swam very much, in fact, so... But I recognize that if I had a lot of back pain that would be one of the exercises that would be best for me and a lot of my colleagues—because of our sedentary life, they have back pain, and you know, that's a very, very good exercise. So I don't swim very much, but it's not because of my studies.

AHEARN: Well, Dr. Kogevinas, thank you so much.

KOGEVINAS: Thanks to you.

AHEARN: Dr. Manolis Kogevinas is a professor and co-director of the Centre for Research in Environmental Epidemiology in Barcelona, Spain.

And that's *The Researcher's Perspective*. I'm Ashley Ahearn. Thanks for downloading!

References and Notes

[1] Richardson SD, et al. Mutat Res 636(1–3):178–242 (2007); doi:10.1016/j.mrrev.2007.09.001.
[2] Richardson SD, et al. Environ Health Perspect 118(11):1523–1530 (2010); doi: 10.1289/ehp.1001965.
[3] Kogevinas M, et al. Environ Health Perspect 118(11):1531–1537 (2010); doi: 10.1289/ehp.1001959.
[4] Font-Ribera L, et al. Environ Health Perspect 118(11):1538–1544 (2010); doi: 10.1289/ehp.1001961.
[5] Font-Ribera L, et al. Am J Respir Crit Care Med; doi:10.1164/rccm.201005-0761OC [online 1 Oct 2010].

[6] Competitive ("elite") swimmers have been shown in several studies to have a higher prevalence of upper respiratory illnesses, allergies, and asthma than the general population. See Bougault V. Sports Med 39(4):295–312 (2009); doi:10.2165/00007256-200939040-00003.

[7] In their study Kogevinas and colleagues observed an increase in urine mutagenicity and in the number of micronuclei in blood lymphocytes (white blood cells). Urine mutagenicity means potentially DNA-damaging compounds were detected in subjects' urine, indicating the subjects had been exposed to an agent that can cause DNA damage. An increased number of micronuclei in lymphocytes indicates chromosome damage may have occurred. Both these molecular-level changes have been associated with cancer in other studies.

[8] DBPs in drinking water typically derive from organic compounds that collect in reservoirs, such as algae and humic acids from decayed leaves.

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